Why does Switzerland promote

Fuel Additives

but absolutely prohibit

the use of such Fuel Additives

without

appropriate Particulate Traps

Why Switzerland promotes Fuel Additives but absolutely prohibits use FA without appropriate Traps

Why Promoting ?

- FA reduce engine-out particulate by > 25 %
- FA lower soot combustion temperature by >200 °C
- FA support nearly every trap technology
- FA can be applied for the dirtiest engine technology
- FA still work when other trap technologies fail
- FA catalyze conversion of other pollutants (CO, HC)
- FA are an indispensable tool for retrofit trap technology

Why Limiting ?

- FA are mostly heavy metals – emitted as oxides
- FA-oxides are toxic substances
- FA emissions can be reduced to < 0,1 % by traps (BAT)
- Swiss EPA is very much concerned about heavy metal emission in general even at trace concentrations
- Swiss EPA did always limit/prohibit heavy metals in fuels

Additive-Substances

Substances

- Copper
- Manganese
- Iron
- Cerium
- Platinum
- Strontium
- X
- X
- Combinations

- **Concentrations** starting with 50-100 ppm
  now in the range of 10-20 ppm !

- **Regeneration Temperature** starting with 450 °C
  now in the range of 300 –350 °C !

→ further development to be expected

Swiss Fuel Additive Regulations

1. Registration by Swiss EPA as “new substance”
2. Toxicity rating by Ministry of Health
3. Check of soil/water pollution (reclaiming) properties
4. Secondary Emissions Test VSET
5. Each Trap System using FA must pass VFT
   with the FA in the highest ever expected concentration
6. Automatic onboard dosing system or equivalent
7. Electronic trap control with dosing-stop if trap fails
8. Manufacturer declaration “FA excl.used with Traps”
9. Declaration on FA-containers “only use with xx-trap”
10. Method of environmentally friendly ash removal

These rules are legally based on EJPD-Regulation August 1990
“Particulate traps can be retrofitted but need to be tested with respect to noise, safety and the formation/emission of new toxic substances”

What are Fuel Additives FA

or Fuel Catalysts
or Regeneration Additives

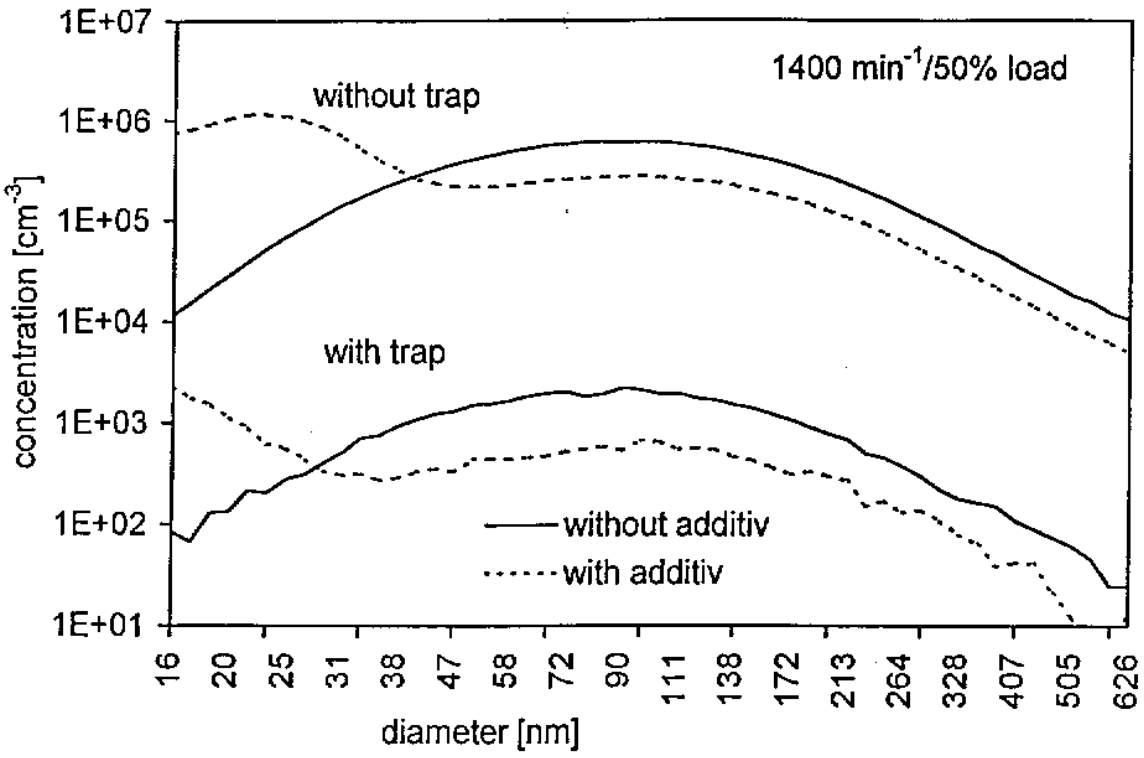
- Fuel Additives are mainly metal-organic compounds perfectly dispersed in fuel on molecular basis
- Metals (usually transition metals) form oxides which are catalytically active to accelerate soot oxidation in the engine itself and traps

Problem Areas:

- Oxide particles deposited in trap tend to gradually clog the trap (→ backpressure increase, fuel economy impact)
- Cleaning traps from FA-ashes needs maintenance (every 2000 op.hours)
- FA-ashes can be agressive to the trap material
- Secondary toxic compounds may be generated

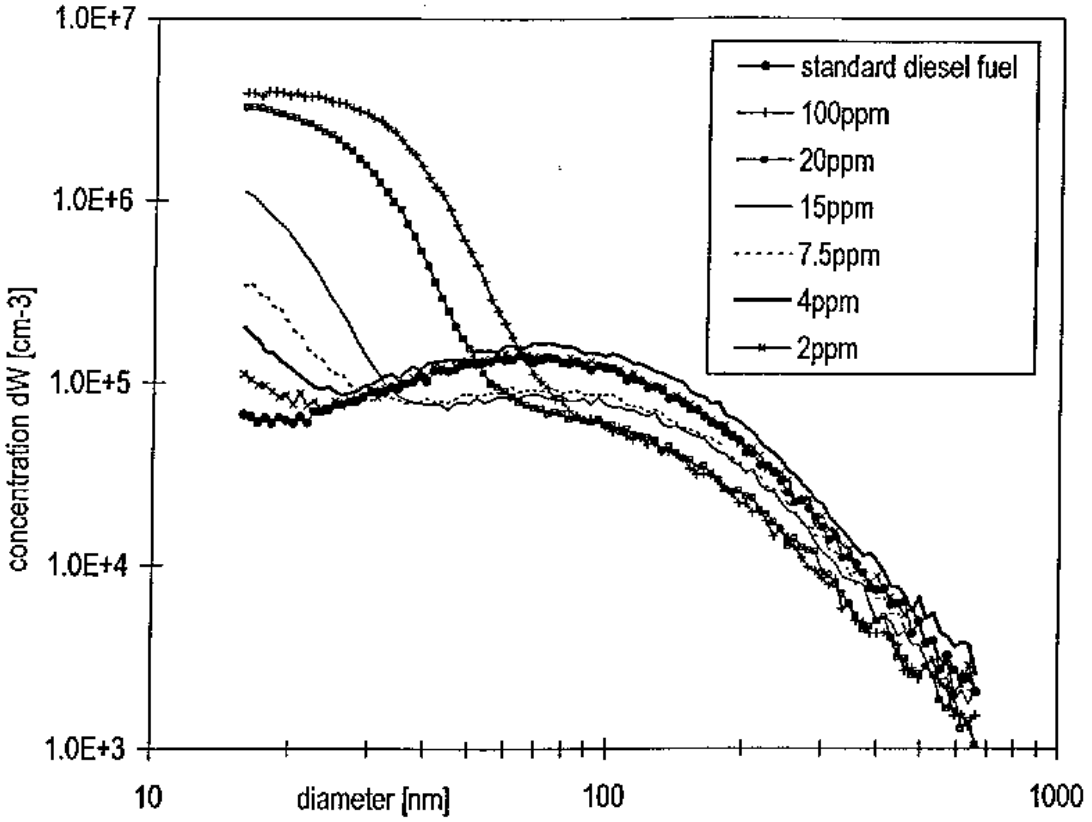
Where are the Additive Oxides left?

- Some coat the engine surfaces (catalytic activity) mainly in the initial phase
- Some end up in the lube oil (effects unknown)
- Some leave the engine attached to soot particles
- Some leave the engine as small oxide clusters



VERT-data with transition metal additives
Concentration: 100 ppm Ce

Additive Emission Characteristics strongly depend on Concentration



Swiss Trap-System Certification Test

Consists of 3 Parts

Part 1: Filtration Test + Secondary Emission Test

Part 2: Field Test 2000 hrs

Part 3: Repetition of Filtration Test

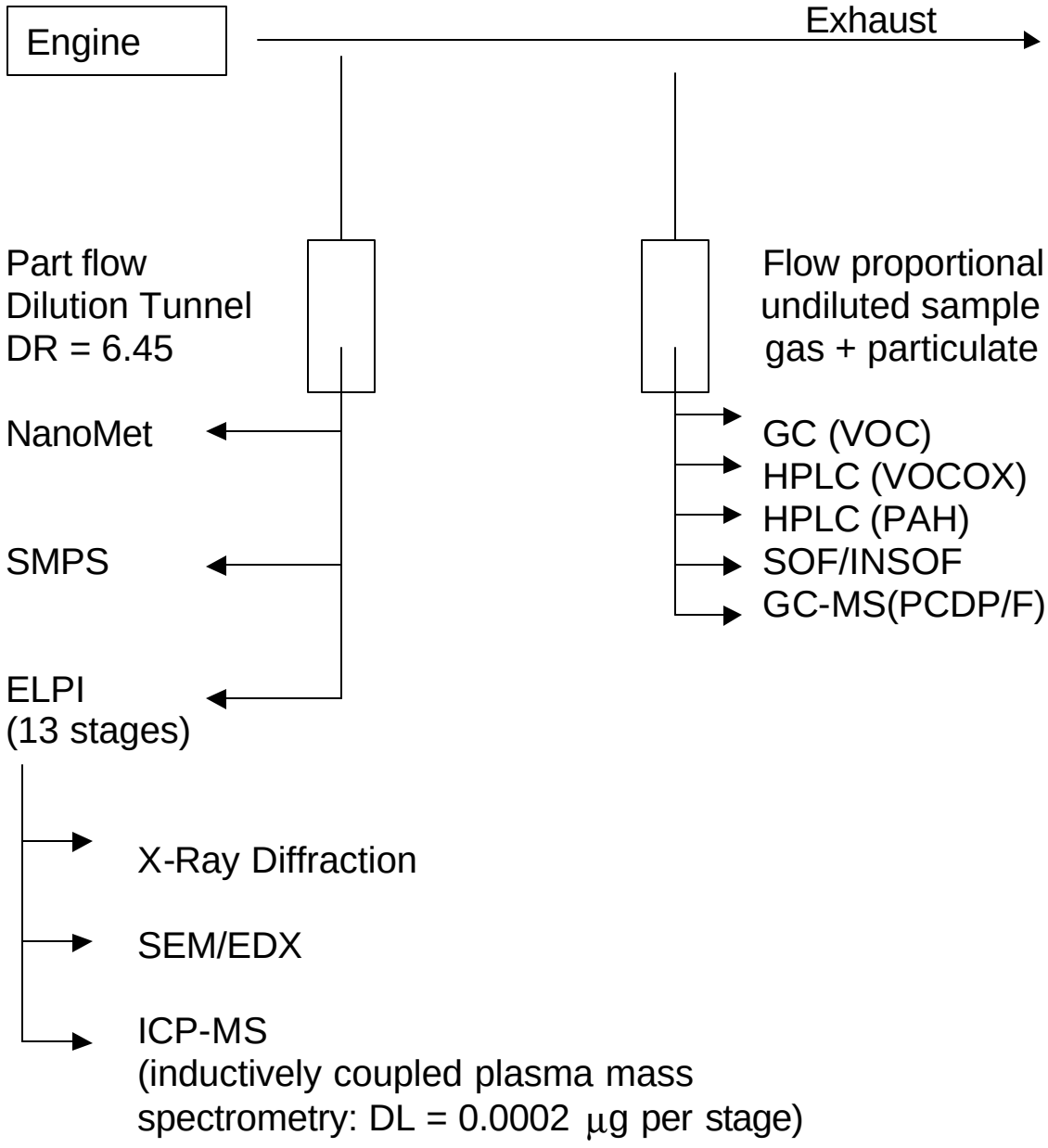
Part 1: Filtration Test: VFT

- Cycle: ISO 8178 C1, 4 stationary points
  + free acceleration
- Trapping efficiency: Mass / BS / EC / OC / Number / Surface
- Emissions during regeneration

Part 1 – Secondary Emission Test: VSET

- Cycle: ISO 8178 C1: 8 points including transients: 200 min.
- Chemical Sampling and Analysis (EMPA 17 28 47)
  PCDD/F, PAH, Nitro-PAH, SOF/INSOF
- Particulate Sampling: ELPI, SMPS, NanoMet
  → how many particles are emitted?
  → in which size range?
  → what is their chemical composition?
  → what is their surface morphology?
  → what is their crystalline structure?

Test – Setup for VSET
VERT Secondary emission test



Size Specific Chemical Analysis for Ce

By ICP – MS / DL = 0.001 µg/stage

ELPI Stage	Diameter D50 [nm]	upstream Trap [µg]	downstream Trap [µg]	Trapping eff. [%]
1	30	0.28	-	
2	63	0.47	-	
3	109	0.51	0.02	
4	173	0.39	0.09	
5	267	0.78	0.11	
6	407	1.02	0.13	
7	655	0.94	0.02	
8	1021	0.58	0.007	
9	1655	0.42	0.003	
10	2520	0.33	0.002	
11	4085	0.29	0.001	
12	6560	0.23	0.002	
13	9999	0.18	0.001	
	Sum:	6.42 µg	0.38 µg	94%

Balance per Test

Total Ce-Input ***324 mg***

Total Ce-Content in Exhaust **25,29** ***mg***

Total Ce-Content in Exhaust downstream Trap **1.52** ***mg***

Deposited in engine ***92.2%***

Deposited in trap ***94%***

Deposited in trap + engine ***99.5%***

Conclusions

- Fuel Additives are an indispensable element in the Diesel particulate reduction toolbox

- FA are a very cost-effective tool
- Expertise and extensive field experience is available

- FA can be toxic ➜ emission must be minimized

- FA can support production of other toxic substances

- Use of FA can only be permitted in combination with very efficient nanoparticle-filtering trap systems

- Electronic onboard leakage control is a must
